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Comparative study of mean Glandular dose between two Mammography Systems with Similar Target – Filter Combination

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ABSTRACT

Mean Glandular Dose is a tool for optimization of the mammography parameters which ultimately helps to determine limits for the breast dose and a better understanding of cancer risk. The objective of this study was to compare the Mean Glandular Dose (MGD) between a Full-Field Digital Mammography system and a Computed Radiology system both using the same fixed target/filter combination with automatic exposure mode. The study was also carried out to determine the MGD using the American College of Radiology Mammography Accreditation Phantom (ACR MAP). The mean glandular dose was measured for a breast phantom of thicknesses (20, 30, 40, 45, 50, 60, and 70) mm for the two mammography units and found to be within the acceptable limit. The MGD of the ACR MAP of thickness 42 mm was found to be 1.44mGy and 1.36mGy when exposed at 28kVp for the two units and were within the acceptable limit of less than 3.00 mGy. Comparatively, the doses delivered by the Full-field Digital mammography equipment were higher than doses delivered by the Computed Radiology equipment. It is recommended that both mammography units should be continually used for mammography examination.

Keywords: Mammography, Mean Glandular Dose, Full Field Digital Mammography, Target – Filter Combination

I. INTRODUCTION

Breast cancer is not only the most common cancer among women throughout the world but is also the most frequent cause of cancer death in women [1]. Mammography is a radiological diagnostic method in medicine which images the breast [2]. Mammography is the number one option for diagnosing breast cancer [3]. The main purpose of mammography is for early detection of the abnormalities in the breast tissue before they develop into breast cancer, typically through detection of characteristic masses and/or micro calcifications. While it is used primarily for the detection and diagnosis of breast cancer, mammography also has value in pre-surgical localization of suspicious region and in guidance of biopsies [4]. In mammography, the Mean Glandular Dose (MGD) is the term used to describe the most appropriate dosimetric quantity to predict the risk of radiation induce to the breast [5]. The mean glandular dose is defined as the average dose to the glandular tissue and it is generally assumed that the glandular tissue of the breast is most vulnerable to the induction of cancer by ionization radiation [6]. The MGD depends on: the quality of radiation i.e. the half-value layer (HVL), anode/filter combination, radiation detector (screen-film, digital radiography, computed radiography), and thickness and composition of breast as well as exposure parameters. [7, 8, 9]. Since breast is one of the most sensitive organs to ionizing radiation, it is important to compare and evaluate absorbed dose to this organ especially to the glandular parts. The x-ray used in mammography are produced from molybdenum, rhodium or tungsten or a combination of any two of them as anode or target material [4]. Earlier work suggest that a combination of the tungsten/rhodium (W/Rh) exhibited lower mean glandular doses [10].

The main objective of this study is to compare the Mean Glandular Dose values between a Full Field Digital Mammography (FFDM) system and Computed Radiology (CR) system having the same target/filter combination to ensure effective optimization of radiation protection in mammography practices.

II. METHODS AND MATERIAL

A. Materials

Breast phantom slabs made of polymethylmethacrylate (PMMA) also known as acrylic or acrylic glass, One Full Field Digital mammography (FFDM) system, a Computed Radiology (CR) system, both using a fixed Tungsten/Rhodium (W/Rh) target/filter combination were used for the study. The characteristics of mammography units used are shown in table 1. American College of Radiology (ACR) Mammography Accreditation Phantom (MAP) and Microsoft excel application were also used.

Table 1 : Characteristics of Mammography systems used for the study

Characteristics	FFDM	CR
System Type	Varian Medical Systems	Philips
Year Installed	2012	2015
Model	Fujifilm – AMULET F	MammoDiagnost AR
Source - Image distance (mm)	650	650
Applied Anode/filter type	W/Rh	W/Rh
kVp range	23 - 35	20 – 35
mAs range	2 - 600	1 – 640

B. Methods

Experiment 1

FFDM system

A 20 mm PMMA phantom slab was positioned centrally and 50 mm away from the edge on the breast support. With the help of the compression plate the PMMA was compressed. The distance between the plate and the compression plate was measured on each corner equally to avoid misalignment. Set-up is presented in figure 1. Automatic Exposure Control mode was selected and exposure was made. Reading for Mean Glandular Dose (MGD) was recorded. The same procedure was repeated for 30 mm, 40 mm, 45 mm, 50 mm, 60 mm and 70 mm phantom thicknesses and their corresponding reading of MGD were recorded.

Figure 1: Set –up for experiment 1

CR system

Set – up remained the same as for FFDM system. After exposure, reading of Incident Air kerma and half value layer were recorded from the screen. The incident air kerma was corrected for using the Inverse Square Law, equation 1,

$$\frac{I_1}{I_2} = \frac{(d_2)^2}{(d_1)^2} \qquad 1$$

where I_1 and I_2 are the initial and final intensity of radiation respectively and d_1 and d_2 are the initial and final distances respectively and the Mean glandular dose calculated using the equation 2:

$$MGD = Kgcs \qquad 2$$

where K is the incident air kerma, g and c are conversion factors and s is a conversion factor that depends on the target filter combination.

The same procedure was repeated for 30 mm, 40 mm, 45 mm, 50 mm, 60 mm and 70 mm other phantom thicknesses and their corresponding readings of MGD were recorded.

Experiment 2

FFDM system

American College of Radiology (ACR) Mammography Accreditation Phantom (MAP) breast phantom of thickness 42 mm was placed on the breast support and compressed. Exposure was made using semi - automatic mode with a tube voltage of 28 kVp. Set-up is presented in figure 2. The reading for MGD was recorded.

Figure 2: Set –up for experiment 2

CR system

Exposure was made using semi-automatic mode with a tube voltage of 28 kVp. Readings for kVp, mAs, compression force and Incident Air kerma and half value layer were recorded from the screen. The incident air kerma was corrected for using the equation 1 and the Mean glandular dose calculated using the equation 2.

III. RESULTS AND DISCUSSION

Results of MGD values from both systems were compared to acceptable limits from the European guidelines for quality assurance in breast cancer screening and diagnosis - Fourth edition.

From experiment 1, MGD for both mammography units were generally within the acceptable limit. The MGD for the FFDM at 20 mm and 30 mm were found to be higher than the acceptable limit by 12.20% and 1.98% respectively.

Table 2: Characteristics of Mammography systems used for the study

PMMA (mm)	EQUI. BREAST (mm)	ACCP. LIMIT (mGy)	FFDM MGD (mGy)	CR MGD (mGy)
20.00	21.00	1.00	1.13	0.92
30.00	32.00	1.50	1.53	1.06
40.00	45.00	2.00	1.68	1.36
45.00	53.00	2.50	1.83	1.62
50.00	60.00	3.00	1.88	2.11
60.00	75.00	4.50	2.57	3.55
70.00	90.00	6.50	3.59	5.01

The MGD was observed to increase with increasing breast thickness for both mammography units. MGD from the study has been compared graphically with acceptable dose from internationally recognized organization. Figure 3 shows the variation of MGD per thickness in comparing the MGD for the two mammography units with the acceptable limit.

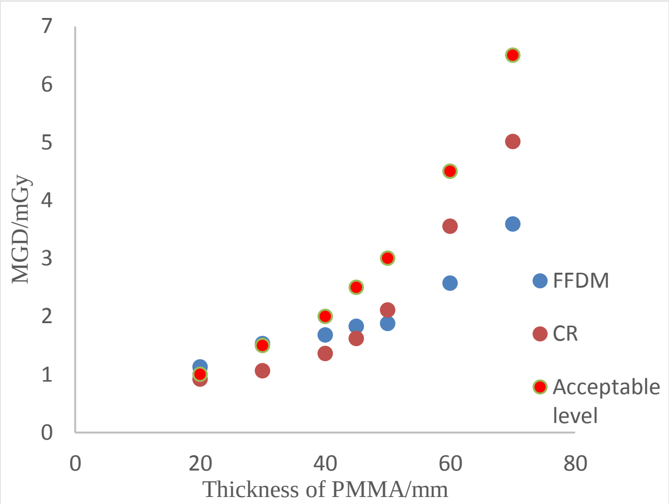

Figure 3 : A graph of Mean Glandular Dose (MGD) against Thickness of PMMA

The MGD for the two mammography units increases with increasing thickness of the phantom and in relating this results to patient’s breast thickness, it indicates that MGD per patient decreases with increasing age since the breast thickness is smaller at higher ages. The results obtained from the study are comparable and in good agreement with other previous studies on mammography examination [11, 12, 13]. The relationship between MGD and breast thickness may be quite useful in retrospective dose assessment of individuals. Comparatively, the MGD for the FFDM unit is higher than that of CR unit except at high thicknesses where the MGD of the CR is higher than the FFDM. At thicknesses below 45mm, the MGDs of the FFDM were higher than that of the CR but at thicknesses above 45mm, the MGDs of the CR were higher than that of the CR.

Results from experiment 2 show that the FFDM mammography unit recorded a MGD of 1.44 mGy and the CR mammography unit recorded a MGD of 1.36 mGy. The results were within the acceptable limit which states that a breast of thickness 42 mm should have a MGD value of <3.00 mGy when exposed at 28 kVp.

IV.CONCLUSION

Comparing the estimated MGD among the units, the doses delivered by the Full-field Digital mammography equipment were higher than doses delivered by the Computed Radiology equipment due to high radiation output of the FFDM. However, the Mean Glandular Doses for the two mammography units were within the internationally acceptable limit with the exception of of the 20 mm and 30 mm phantom thicknesses.

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